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Systematic Review

Comparative Effectiveness of Functional Orthodontic Appliances during the Pubertal Growth Spurt: Twin Block Versus Clear Aligners with Mandibular Advancement Features: A Modified Systematic Review

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Abstract: ***Objectives:*** This systematic review assessed the dentoskeletal effects of Twin Block (TB) and Invisalign clear aligners (CAs) with mandibular advancement features in peripubertal patients compared to Class II non-treated individuals, using lateral cephalography. ***Materials and Methods*:** In this modified systematic review, data were collected electronically by searching PubMed Central, Google Scholar, and Cochrane electronic databases. The outcome measures included SNA, SNB, ANB, Wits appraisal, SN^Gn, U1^PP, L1^MP, overbite, and overjet measured at the onset (T1) and at the end (T2) of functional appliance therapy. ***Results*:** Nine eligible papers were reviewed: 6 on TB and 4 on CAs (1 study included both appliances). Patients' mean age ranged from 11.2 to 13.15 years for the intervention groups, and 10.7 to 13.07 years for non-treated controls. An improvement in sagittal intermaxillary relationships was observed, primarily at the mandibular level, when patients were treated at puberty. This was confirmed by an increase in the SNB angle and a corresponding reduction in the ANB angle between the pre- and post-treatment phases, in comparison to non-treated controls, slightly more pronounced with the TB. Mandibular advancement was associated with an increase in mandibular length (CoGn), significantly greater in both treatment modalities compared to non-treated controls. ***Conclusion:*** This systematic review showed that both appliances produce significant skeletal effects when applied during the pubertal growth phase, emphasizing mandibular protrusion and skeletal growth. The biological timing of intervention may be a critical factor in understanding the divergent findings reported in the literature.

Keywords: Malocclusion, Angle Class II, Orthodontic Appliances, Functional, Orthodontic Appliances, Removable, Systematic Review.

INTRODUCTION

Skeletal Class II malocclusion in growing patients can be addressed through functional treatment aimed at modifying growth by advancing the mandible [1]. Functional appliances, introduced by the Andreason in the 1930s [2], work by posturing the lower jaw forward, thereby stretching muscles and soft tissues, which generate forces transmitted to the dentition. This results in tooth movement leading to a new occlusal relationship and overjet reduction [3].

The Twin Block (TB) appliance is among the functional appliances suggested for mandibular advancement. It is comprised of separate upper and lower plates with bite blocks set at approximately 70 degrees. The lower block postures and locks the mandible forward when the patient occludes. Although the tolerance of TB is generally good, achieving a 24-hour wear schedule remains challenging due to patient compliance issues, and a failure rate of 34% has been reported primarily due to non-compliance [3].

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More recently, clear aligners (CAs) with mandibular advancement features were suggested for mandibular advancement. The advent of IT technologies and 3D printing enabled Align Technology Inc. to launch clear aligners in 1999, originally intended for minor tooth movements, but later evolved to treat more severe malocclusions [4]. In 2017, Align Technology introduced a new feature known as "precision wings" dedicated to mandibular advancement in growing Class II patients who require growth modification [5]. The precision wings, positioned on the upper and lower aligners, posture the mandible forward during occlusion, thereby simulating the TB mechanism for Class II skeletal correction [2]. Unlike the TB, it allows for simultaneous levelling and aligning of the dental arches alongside anteroposterior correction. Depending on clinical needs, a pre-advancement phase of aligners may be used to reduce overjet, procline maxillary incisors in Class II Division 2 cases, expand the upper arch, or derotate upper incisors. During the advancement phase, the mandible is positioned forward by 2 mm every eight stages until an edge-to-edge incisal position is achieved; if a complete correction to Class I is not attainable, additional measures such as upper molar distalization or elastic biomechanics may be implemented [2]. Although the appliance offers improved comfort due to its compact size, palatal space, and esthetic appeal compared to standard removable functional appliances, its success remains largely dependent on patient compliance.

A key difference between functional appliances like TB and CAs is the reliance on patient compliance; removable appliances depend on compliance, which can be low due to discomfort; while, fixed appliances operate continuously but carry a higher risk of failure [3]. CAs with mandibular advancement features offer an intermediate solution: they are removable but designed for comfortable, nearly 24-hour compliance.

Researchers have investigated functional treatment for decades, and extensive data are available on traditional removable and fixed Herbst-type appliances. However, the evidence regarding the effectiveness of CAs with mandibular advancement features remains limited. Various functional appliances are available, with the TB being particularly popular in Poland and Europe. Moreover, existing studies often include patients across a wide age range (combining pre-pubertal and pubertal individuals), despite the importance of craniofacial growth stage and remaining growth rate in planning effective growth modification [6]. According to Baccetti *et al*., [7, 8], the greatest skeletal response occurs when functional treatment is applied close to the pubertal growth spurt. Thus, this systematic review aimed to consolidate current knowledge on the therapeutic potential for growth modification in Class II treatment using TB and CAs. Verifying whether these treatment modalities yield similar responses when used at the optimal time is essential for informing treatment strategies for growing individuals with Class II malocclusion. Furthermore, the methodology of this review can serve as a framework for future studies examining short-term responses to other functional appliances or evaluating the long-term stability of functional treatment outcomes.

Materials and Methods

This modified systematic review was conducted according to the Cochrane Handbook for Systematic Reviews of Interventions 5.1.0, with a modification that article selection and their critical appraisal were performed by one single investigator (KD), and reported based on the PRISMA statement. The study was approved by the University of Bolton Research Ethics Board on 19-Feb-2025 (Certificate number: AUTONOHP00226).

Article Selection:

PubMed Central, Google Scholar, and Cochrane electronic databases were systematically searched by one reviewer (KD). The search strategy employed keywords, such as: “functional treatment” OR “class II functional treatment” OR “class II functional appliance” OR “Twin Block” OR “clear aligners with mandibular advancement” OR “Invisalign with mandibular advancement”. There were no limitations concerning language and publication year at this stage. The reviewer (KD) reviewed the titles and abstracts of the articles and manually searched the reference lists of the retrieved articles and relevant systematic reviews to ensure comprehensive coverage. Duplicate records were eliminated at the pre-selection phase based on title or abstract. Articles were chosen based on their relevance to the skeletal and dental outcomes of Class II functional treatment. If TB or CA treatment was not mentioned in the title, abstracts were used to determine eligibility. Studies meeting the initial criteria -TB or CA treatment in growing patients with reported skeletal and dental outcomes- were selected for final evaluation. Since abstracts alone were often insufficient to confirm the inclusion of peripubertal growing patients and a non-treated Class II control group, the full texts of these studies were retrieved to assess detailed eligibility criteria, with craniofacial growth phase being a critical factor for inclusion.

Selected articles were recorded in an Excel file to facilitate data extraction and document the reasons for exclusion. Due to language limitations, only articles published in English were reviewed.

Eligibility Criteria:

The eligibility criteria for final selection were pre-determined, and a complete list is shown in Table 1. A study was considered eligible if it reported outcomes for TB or CA Class II treatment while meeting all the inclusion criteria and none of the exclusion criteria. Studies reporting treatment results with both appliance types were eligible only if they included a non-treatment Class II control group to facilitate the evaluation of skeletal and dental changes. Since this systematic review focused on peripubertal patients, studies that did not specify circumpubertal age or provide a skeletal maturity evaluation were excluded. Only articles that indicated the inclusion of peripubertal patients were considered eligible; however, a study was not required to select patients based on growth phase if the results reported the growth phase. Studies comparing treatment effectiveness across different growth phases were included if data could be extracted for cervical vertebral maturation (CVM) stages 3 and/or 4. Additionally, studies using chronological age as a surrogate for the circumpubertal phase were deemed acceptable. To isolate the effects of functional treatment, data from subsequent phases involving fixed appliances or aligners were not included.

Initially, the selection was to be limited to high-quality, prospective, randomized trials to ensure the most reliable conclusions. However, due to the limited availability of such studies, and the fact that most cephalometric evaluations of skeletal and dental responses were retrospective, the inclusion criteria were broadened to include retrospective trials. The articles reviewed were to be published between 2004 and 2024, as before 2004, the CVM evaluation was rarely performed, and the relationship between the growth phase and treatment effect was seldom investigated.

Furthermore, cephalometric parameters describing skeletal and dental changes were selected to exclude Pancherz analysis, since it employed parameters not commonly used in routine orthodontic practice. The intent was to demonstrate the effectiveness of functional treatment in the commonly used “cephalometric language” of clinicians.

Methodological Appraisal:

After the final article selection, the methodological quality was evaluated and scored. As most studies were retrospective, the CASP Checklists could not be applied. Consequently, the reviewer (KD) developed a methodological scoring system, referring to the methods from other systematic reviews on this topic. The evaluated criteria are shown in Table 2.

Risk of Bias:

The risk of bias assessment was conducted as part of the data extraction process. This evaluation was carried out by one single investigator (KD). Given that non-randomized studies were selected for inclusion, it was performed based on the ROBINS-I V2 tool. A summarized evaluation was presented visually using the ROBVIS tool.

Data Extraction

Data were extracted using predefined forms developed by the reviewer (KD), capturing variables such as the year of publication, type of intervention (including the appliance used), sample size, mean participant age, sex distribution, and reported outcome measures. During data review, inconsistencies in cephalometric terminology across studies were noted. To ensure clarity and uniformity in outcome presentation, a single standardized term, as preferred by KD, was applied throughout the review.

Skeletal and dental lateral cephalometric measurements were collected, including mandibular and maxillary anteroposterior positions, sagittal intermaxillary relationships, maxillary and mandibular incisor inclinations, overjet, overbite (when available), and vertical dimensions. The initial objective was to extract baseline (T1) and post-treatment (T2) outcome measures for the intervention and non-treated control groups, along with the calculated T2–T1 difference. However, some studies did not explicitly report T1 and T2 data, instead providing only the T2–T1 mean difference (between groups. In other cases, both T1 and T2 values were available alongside the calculated mean difference. To account for these variations, predefined data extraction tables were adjusted, and minor calculations were performed by the reviewer (KD) where necessary. When available, statistical significance of the data was also extracted.

Data Variables:

Post-functional treatment changes at the skeletal and dental levels were the area of interest of this systematic review. Therefore, the effort was performed to evaluate the following primary variables: SNA, SNB, ANB, Wits, CoGn (mm) for sagittal dimension, SN^MP or MPA or FMA for vertical dimension and U1^PP, L1^MP, overjet and overbite for dental changes (Table 3).

RESULTS

Selection Results:

The preliminary search identified 809 articles in PubMed Central, and 2659 in the Cochrane database. This search was supplemented by manual searches in Google Scholar and reference lists, which yielded no additional results. The Cochrane search automatically included studies from PubMed, Embase, ClinicalTrials.gov, and WHO ICTRP registers.

However, 1336 trials from these registers were excluded during the preliminary search due to the unavailability of retrievable reports. After eliminating duplicates, 132 trials remained for abstract screening; of which, 99 were excluded. A total of 43 studies closely related to the topic were selected for full-text review. Among these, 10 papers initially met the inclusion criteria. However, one study [9] was excluded upon detailed review, as it combined post-treatment results for both functional treatment and straight-wire therapy, making it impossible to isolate post-functional treatment data.

Additionally, one study was unavailable for retrieval, while the remaining excluded studies either involved patients outside the target age range, lacked information on growth stages, did not include a non-treated Class II control group, or used non-applicable cephalometric parameters (e.g., Pancherz analysis). The search results are summarized in the PRISMA flow diagram (Figure 1).

Characteristics of Selected Studies:

Ultimately, 9 papers were included in the review, as a search result, that met the inclusion criteria and did not meet any of the exclusion criteria. Table 4 shows characteristics of selected studies. Data were pooled from 6 studies for TB appliance by Gulec and Goymen [10], Gulsoy and Yavan [11], Khoja *et al*., [12]. Lombardo *et al*., [13]. Saikoski *et al*., [14]. Tepedino *et al*., [15], and 4 studies for CA by Al Subaie *et al*., [16]. Blackham [17], Lombardo *et al*., [13], and Ravera *et al*., [18]. Two of eligible studies by Blackham [17], and Lombardo *et al*., [13], included both treatment groups as well as a non-treated class II controls; however, in case of Blackham [17], the TB group was at CVM 2 stage; therefore, this dataset was excluded from the review. The studies were critically appraised for quality, using a 0-1 scoring system. The appraisal results are presented in Table 5.

Six studies were retrospective, and three were prospective; none of them used randomization. Reports by Al Subaie *et al*., [16], and Blackham [17], did not have formulated inclusion and exclusion criteria; however, the generally described criteria fit the assumptions of this systematic review. As most of the selected studies were retrospective and used historical controls collected from a different source than the treatment groups, there was a risk of selection bias. Additionally, potential confounders might not have been properly controlled, leading to a risk of confounding bias. A summary of risk of bias assessment is presented in Figure 2.

Patient Population:

This systematic review was focused on skeletal Class II division 1 patients with mandibular deficiency and horizontal growth pattern, who undoubtedly stayed in the peripubertal growth phase. Similarity of treatment and control groups was desired. When possible, data related to the treatment length and follow-up duration for the control group were pooled. The characteristics of the patient population are presented in Table 6. Studies included patients with a baseline mean age between 11.2 and 13.15 years, and the mean age range of non-treated controls included in this systematic review was 10.7 to 13.07 years. Except for the study by Al Subaie *et al*., [16], sex distribution was similar between treated and non-treated groups. Treatment duration differed from almost one year to one and a half years. In 2 studies, appliance wear time was recommended to be 12-16 hours per day, while in the others, 20-22 hours per day.

Sagittal Skeletal Changes:

Mandibular Position and Length:

The general approach to results presentation differed in different studies. Some authors presented baseline (T1) and post-treatment (T2) values and (T2-T1) difference (Gulec and Goymen [10], Gulsoy and Yavan [11], Khoja *et al*., [12]. Ravera *et al.,* [18]. Saikoski *et al.,* [14], and Tepedino *et al*., [15], while the others presented only (T2-T1) difference for each group (Al Subaie *et al*., [16]. Blackham [17], and Lombardo *et al*., [13]. The difference of post-treatment effect between groups was calculated only in the reports of Al Subaie *et al*., [16]. Lombardo *et al*., [13], and Tepedino *et al*., [15]. In the case of the remaining studies, only p-value was available, indicating statistical significance of inter-group differences, and a simple calculation of T2-T1 difference between groups (excluding standard deviation) was performed by the reviewer (KD). The mandibular position was reviewed based on the SNB angle while the mandibular length was evaluated using Co to Gn distance.

The anteroposterior mandibular position changed after functional treatment into the more anterior direction (SNB angle increase) in most studies, except for Gulec and Goymen [10], who reported a non-significant -0.66-degree reduction of SNB (Table 7). The SNB increase after TB treatment differed from 1.15 ± 0.98 degrees to 2.32 ± 1.28 degrees. Non-treated groups noted the change of less than 1 degree. The reported differences between the groups fluctuated between 0.97 degrees (Khoja *et al*., [12]. CS4) to 1.87 degrees (Tepedino *et al*., [15], and they were statistically significant in most studies, except for Lombardo *et al*., [13], Saikoski *et al*., [14], and Gulec and Goymen [10]. In the case of CA studies, the T2-T1 SNB mean change after CA treatment did not exceed 1.4 ± 3.2 degrees (Lombardo *et al*., [13], and the statistically significant difference between groups (1.2 degrees) was reported only by Al Subaie *et al*., [16]. (Table 7).

Elongation of mandibular length measured by Co to Gn distance after treatment with TB appliance differed from

4.15 ± 3.53 mm to 8.69 ± 2.32 mm (Table 7). In the case of non-treated Class II patients, Co-Gn value changes were smaller: 1.24 ± 2.92 mm to 4.57 mm. Differences in the mandibular elongation between the groups ranged between 2.5 mm and 9.97 mm and were statistically significant in all cases. The results for CAs were comparable, and the reported T2-T1 change differences between the groups fluctuated between 0.33 and 8.75 mm. However, statistically significant differences of T2-T1 results between the groups were reported only by Lombardo *et al*., [13], and Ravera *et al*., [18]. (Table 7).

Maxillary Position:

Maxillary position was measured as the SNA angle. Most authors reported SNA change < 1 degree for TB and CAs, as well as non-significant differences between the intervention and non-treated groups (Table 8).

Intermaxillary Relationship:

The intermaxillary relationship was measured by the ANB angle and Wits appraisal. Five out of 6 selected studies reported a significant reduction in the ANB angle for patients treated with TB when compared to the non-treated control group (mean T2-T1 ranged between -1.06 degrees and – 2.07 degrees). In CA studies, T2-T1 change between groups was slightly less pronounced and ranged between -0.9 degrees and -1.7 degrees (Table 9).

The T2-T1 mean Wits reduction after TB therapy ranged between -1.1±2.9 and -2.85 ±1.89 (Table 10). Only Tepedino *et al*., [15], reported a significant reduction of Wits after TB treatment compared to non-treated controls (-3.25 ± 0.79 mm). In the case of CA studies, it fluctuated from -1.2 to –3.73 mm and was statistically significant in most studies (Table 9).

Vertical Skeletal Changes:

The impact of functional treatment on the vertical dimension was evaluated either by SN^GoGn angle or by the intermaxillary angle (MPA) or FMPA angle. Authors of the reviewed studies used different outcome measures for vertical dimension assessment; thus, it was impossible to analyse one coherent variable for this systematic review. In TB studies, the changes in the vertical dimension in the treatment groups ranged from a slight reduction (-0.53 degrees) to an increase of Sn^GoGn angle up to 1.84 degrees (Table 10). In CA studies, none of the studies reported a significant T2-T1 change difference in SN^GoGn angle between treated and non-treated groups (Table 10).

Dental Changes:

The inclination of upper incisors is usually measured either to the cranial base (U1^SN) or to the horizontal plane (FH) or the maxillary (palatal) plane (ANS-PNS/ PP). Most studies evaluated the inclination of a maxillary central incisor using the U1 to PP angle. The exceptions were Gulec and Goymen [10], who evaluated U1^FHP angle and Khoja *et al*., [12], who evaluated U1^ SN angle. Among the studies investigating the effectiveness of TB, Gulsoy and Yavan [11], Khoja *et al*., [12], and Saikoski *et al*., [14], observed significant differences in the upper incisors' position after functional treatment compared to the untreated control group. Except for Lombardo *et al*., [13], the rest of the studies reported a reduction of an upper incisor's inclination (up to -7± 6.41 degrees by Saikoski *et al*., [14], with the biggest difference between the treated and non-treated groups of -7.77 degrees (Table 11). In the case of functional treatment with CAs, none of the studies observed significant differences in the upper incisor's position after functional treatment compared to the untreated control group. However, looking at the standard deviations, the individual response must have been differentiated (Table 11).

The position of lower incisors is usually measured to the mandibular plane (L1^MP/ IMPA). Among the studies investigating TB effectiveness, only Gulsoy and Yavan [11], and Khoja *et al*., [12], (both populations) reported a significant increase in the inclination of lower incisors after functional treatment compared to the untreated control group (Table 11). The difference between the groups in T2-T1 change ranged from 1.20 degrees to 5.48 degrees. In the case of CAs, none of the studies observed significant differences in lower incisor's position after functional treatment compared to the untreated control group; however, the standard deviation was usually higher than the mean results themselves, indicating high diversity of the results (Table 11).

Overjet:

All the studies observed a significant reduction of overjet after functional treatment with TB, compared to the untreated control group. It differed from -1.6 ± 4.8 mm to -7.25± 2.20 mm in the intervention groups and from 0.13±1.03 mm increase to -0.52 ± 1.24 mm of overjet reduction. The T2-T1 difference between the treated and non-treated patients ranged from -1.6 mm to -7.39 (Table 12). In the case of mandibular advancement with CAs, a significant difference in the overjet after functional treatment compared to the untreated control group was observed by all the studies except for Ravera *et al*., [18], who did not report any results for the overjet. Post-treatment changes of the CA groups' overjet ranged from -0.5 ± 7.0 to 3.03 ± 2.54 mm with the biggest T2-T1 difference of 2.95 mm in comparison to the non-treated controls (Table 12).

Overbite:

T2-T1 results of patients treated with TB usually indicated a slight reduction of overbite, except for Lombardo *et al.,* [13], who reported a mean overbite increase of 1.1±4.3 mm (Table 12). Overbite reduction fluctuated from -0.03±1.98 mm to 1.78±2.08 mm. The biggest difference between the treated and non-treated patient populations was observed by Gulsoy and Yavan [11] (-1.95 mm), and it was statistically significant (p=0.010). In the case of CAs, a significant difference in the overbite after functional treatment compared to the untreated control group was observed only by Lombardo *et al*., [13], who reported –1.0 ± 7.9 mm T2-T1 reduction of overbite in the CA group, but 0.7 ± 1.6 mm increase of overbite in non-treated controls, which resulted in 1.7 mm difference between the treated and non-treated groups (Table 12).

DISCUSSION

This systematic review aimed to consolidate current knowledge on the therapeutic potential for growth modification in Class II treatment using TB and CAs.

Sagittal Outcome Measures

This systematic review confirmed the effectiveness of both TB and CAs with mandibular advancement features in correcting sagittal intermaxillary relationships, as demonstrated by a reduction in the ANB angle in most studies. Exceptions were noted by Saikoski *et al*., [14]. Tepedino *et al*., [15], and Ravera *et al*., [18]. The mean ANB reduction with TB generally did not exceed 2 degrees, with most studies reporting decreases of at least 1.5 degrees, while untreated groups showed minimal change. Greater reductions were observed in more severe Class II cases (Khoja *et al*., [12]. CA outcomes were comparable but slightly smaller (≤ 1.66 degrees), with high variability. Since ANB is influenced by craniofacial growth direction (Hussels and Nanda [19], the present review focused on horizontally growing patients.

ANB reduction was primarily driven by increases in SNB, indicating mandibular advancement. Significant SNB increases were reported in four of seven TB studies (up to 2.32 degrees; Khoja *et al*., [12], whereas CA studies showed smaller, mostly non-significant changes (≤1.4 degrees; Lombardo *et al*., [13]. This suggests that TB may provide more effective mandibular repositioning, likely due to its rigid advancement mechanism, while aligner flexibility may reduce skeletal stimulation.

Changes in SNA were minimal and similar across treatment and control groups, indicating limited maxillary contribution. This aligns with growth patterns, as maxillary growth typically precedes mandibular growth (Midori [20], limiting the impact of late functional treatment on maxillary position. The Wits appraisal findings supported these results, with reductions up to 2.85 mm (TB) and 3.44 mm (CAs), compared to no change in controls.

These findings are consistent with previous literature. Toth and McNamara [21], and Illing *et al*., [22], reported ANB reductions mainly due to SNB increases. Perinetti *et al*., [23], found similar effects in pubertal patients (−1.94 degrees), with smaller changes prepubertally. Likewise, Ehsani *et al*., [24], reported SNB increases (1.2 degrees) and minimal SNA reductions, suggesting mandibular-driven correction. Caruso *et al*., [25], observed larger ANB reductions, particularly with TB, possibly due to additional maxillary effects, although this contrasts with most studies. He *et al*., [26], reported comparable outcomes between TB and aligners with a TB-like advancement mechanism. Yu *et al*., [27], also found no significant differences between CAs and functional appliances, although heterogeneity in appliance types limits interpretation.

Mandibular Length:

The effect of functional appliances on mandibular growth remains debated. While some authors [21-28], reported significant increases, others found no effect [29]. In this review, all TB studies reported significant increases in mandibular length (Co–Gn), and similar increases (>8 mm) were observed in CA studies. Untreated patients showed approximately half this growth, supporting the role of functional appliances in enhancing mandibular development.

These findings align with Stahl *et al*., [30], who demonstrated reduced mandibular growth in untreated Class II patients during puberty. However, smaller effects were reported by Perinetti *et al*., [23]. (3.8 mm) and Ehsani *et al*., [24]. (2.9 mm), likely due to inclusion of prepubertal patients. Cone-beam computed tomography evidence [31], suggests that TB stimulates condylar growth, increasing mandibular length and intercondylar distance. Yu *et al*., [27], reported slightly greater ramus growth with traditional functional appliances compared to CAs.

Vertical Dimension:

Neither appliance demonstrated clinically significant effects on vertical dimensions (SNGoGn, MMPA). Some studies reported minor changes, with TB showing slight increases and CAs occasionally showing small reductions [13-18]. Overall, findings were inconsistent across studies [24-32]. Yu *et al*., [27], concluded that CAs had no effect on mandibular inclination; while, Caruso *et al*., [25], and Wu *et al*., [33], found no differences between appliances.

These inconsistencies may reflect differences in appliance design and bite control. TB may promote molar extrusion due to bite block adjustments; whereas, CAs limit extrusion through full tooth coverage, offering better vertical control.

Dental Changes:

TB and CAs demonstrated distinct dentoalveolar effects. TB consistently produced significant upper incisor retroclination (up to −7.00 degrees; Saikoski *et al*., [14], whereas, CAs showed minimal changes, indicating better incisor control. Lower incisor proclination was observed in TB studies but was generally not significant; CAs showed negligible effects.

Both appliances reduced overjet, with greater changes seen in TB. Overbite reduction was also slightly greater with TB, while controls showed no change. These findings are consistent with Ehsani *et al*., [24], who attributed TB-induced incisor retroclination to labial bow mechanics and lip pressure. Daokar and Sharma [32], reported similar results. Yu *et al*., [27], found no significant differences between CAs and functional appliances; whereas, Caruso *et al*., [25], reported greater upper incisor and overjet changes with TB.

The improved control observed with CAs is likely due to full crown coverage, which allows better management of incisor inclination and may benefit patients with proclined incisors requiring controlled correction.

Factors Affecting Treatment Outcomes:

Patient compliance is a critical determinant of treatment success with removable appliances. However, most included studies did not report actual wear time. Al Moghrabi *et al*., [34], found that patients wore appliances approximately six hours less than recommended, with over half classified as non-compliant. Compliance is influenced by appliance type, malocclusion severity, and parental support [35], while, increased overjet may enhance motivation [36].

Strategies to improve compliance include parental involvement, clinician motivation, and behavioral techniques [35], although reminders such as text messages appear ineffective [37]. Frilund *et al*., [38], reported an average wear time of 6.5 hours/day, with no improvement from increased follow-up frequency. Importantly, Parekh *et al*., [39], and Sarul *et al*., [40], demonstrated that part-time wear (≥ 7–8 hours/day) may be sufficient, suggesting more patient-friendly protocols.

CAs may improve compliance due to esthetics and comfort, although they require longer daily wear (≈22 hours). Patient-reported outcomes [41], indicate that TB is perceived as more visible and prone to breakage; whereas, CAs are easier to use but associated with more dental discomfort. Overall satisfaction and treatment adaptation were similar between groups.

Study Limitations and Strengths

This review was limited by the small number of eligible studies, lack of randomized trials, and reliance on predominantly retrospective designs, introducing potential selection bias. Variability in treatment protocols, follow-up durations, and patient characteristics contributed to heterogeneity. The frequent use of historical controls and absence of compliance data further limit comparability. Additionally, only short-term outcomes were assessed.

Despite these limitations, strengths included consistent cephalometric measurements, focus on a homogeneous peri-pubertal population, and inclusion of untreated controls, enabling differentiation between treatment effects and natural growth.

Given the limitations and heterogeneity of the available evidence, further high-quality randomized controlled trials are needed. Future studies should incorporate standardized protocols, detailed compliance reporting, and long-term follow-up. Nevertheless, this review highlights that effective skeletal correction can be achieved with both appliances when treatment is appropriately timed during puberty, supporting individualized treatment planning for growing Class II patients.

Table 1: Article eligibility criteria

Criteria	Inclusion	Exclusion
Study Design	Randomized and non-randomized, prospective or retrospective studies.	Case studies, case series, qualitative studies, expert opinions, and article reviews.
Treatment Focus	Effectiveness of Class II treatment with Twin Block and/or clear aligners with mandibular advancement features.	Studies include functional treatment combined with headgear or straight wire appliance, without the possibility of functional treatment data extraction. Research on surgical or extraction treatment.
Control Group	Non-treated Class II individuals.	Single-arm studies

Measurement Method	Lateral cephalogram-based studies providing angular and linear skeletal and dentoalveolar measurements (SNA, SNB, ANB, CoGn, SN^MP or MPA, U1^PP, L1^MP).	Studies based on Pancherz analysis or MRI assessment. Digital model analysis.
Publication Language	Articles published in English between 2004 and 2024.	Non-English literature.
Patient Criteria	Patients with skeletal Class II (ANB ≥ 4) and horizontal growth pattern.	Studies including non-growing Class II patients or patients with vertical growth patterns.
	Growing patients near pubertal growth spurt based on CVM (CS 3-4), hand-wrist radiogram (MP3Cap stage), or ages 11-14 years.	Studies that include patients with genetic syndromes.

Table 2: Critical appraisal criteria used in the current systematic review

I.	**Study Design**
1.	The study objective was formulated clearly: 0. NO / 1. YES
2.	Population—described 0. NO / 1. YES
3.	The selection criteria are clearly described and adequate 0. NO / 1. YES
4.	The sample size was adequate and statistically estimated before the collection of data 0. NO/ 1. YES
5.	Randomization was used for sampling 0. NO/ 1. YES
6.	Similar baseline characteristics of the intervention and control groups at the study start 0. NO/ 1. YES
7.	Co-interventions 0. PRESENT/ 1. ABSENT
8.	Timing RETROSPECTIVE/ 1. PROSPECTIVE
II	OUTCOME MEASURES
9.	Measurement method —appropriate to the objective 0. NO/ 1. YES
10.	Blinded evaluation of outcome measures (blinded examiner) 0. NO/ 1. YES
11.	Reliability testing described 0. NO/ 1. YES
III.	STATISTICAL ANALYSIS
14.	Statistical tests were planned for the data analysis 0. NO/ 1. YES
15.	Statistical significance level (p-value) reported 0. NO/ 1. YES
16.	Precision of the estimation (Confidence Interval) reported 0. NO/ 1. YES
17.	Confounders (e.g. co-interventions) included in the analysis 0. NO/ 1. YES
18.	Drop-outs included in the analysis 0. NO/ 1. YES
IV.	**TOTAL SCORE**

Table 3: Cephalometric measures used in Class II malocclusion diagnostic process

Dimension	Measure	Description	Normal Range
Sagittal	SNA	Indicates sagittal maxillary position. It is the angle between the cranial base (SN Line) and the vertical line from Nasal to A point.	82 ± 2 degrees
Sagittal	SNB	Indicates anteroposterior position of mandible. It is the angle between the cranial base (SN line) and vertical NB line (Nasion to mandibular B point).	80 ± 2 degrees
Sagittal	ANB	Indicates the sagittal relationship between the maxilla and mandible It is the angle between the vertical NA and NB lines.	2 ± 2 degrees
Sagittal	CoGn	Used for a measure of overall mandibular length. It is a distance between Co (Condylion) and Gn (Gnathion).	120 ± 4 mm
Sagittal	WITS	Indicates the sagittal relationship between mandible and maxilla (independent of cranial base). It is a distance between points AO and BO (projections of points A and B to the functional occlusal plane).	0 ± 2 mm
Vertical	SN^GoGn	Indicates the vertical dimension of the bite and demonstrates the direction of craniofacial growth. It is the angle between the SN line (cranial base and the GoGn line (mandibular plane).	32 ± 3 degrees
Vertical	MPA	Indicates the vertical dimension of the bite and demonstrates the direction of craniofacial growth. It is the angle between the mandibular and palatal planes.	20 ± 7 degrees
Vertical	LAFH	Used for a measure of the face’s length, especially in terms of mandible vertical growth. Lower anterior face height measured as a distance from ANS to Menthon.	71 ± 6 mm
Dental	U1^PP	Used for the evaluation of the inclination of upper incisors. It is the angle between the long axis of the upper central incisor and the palatal plane.	110 ± 5 degrees
Dental	L1^MP	Used for the evaluation of the inclination of lower incisors. It is the angle between the long axis of the lower central incisor and the mandibular plane.	90 ± 5 degrees
Dental	Overjet	Anteroposterior overlap of upper and lower incisors.	2 ± 1 mm
Dental	Overbite	Overlap of the maxillary incisors over the mandibular incisors is measured relative to the incisal ridges.	20 - 30%

Table 4: Characteristics of selected studies

Article	Appliance	Study type	Patients enrolled		Age		Inclusion characteristics			
			Tx-Group	Control group	Tx-Group	Control group	Inclusion based on the stage of growth	CVM	Class II inclusion	Inclusion ANB
Gulec and Goymen (2018)	TB	retrospective	15	10	12.18 ± 2.19	12.77 ± 1.62	peak of pubertal growth spurt	CVM III-IV	Class II Division 1 malocclusion with at least half cusp Class II molar relationship and a retrognathic mandible	N/A
Gulsoy & Yavan (2022)	TB	retrospective	15	15	12.34±1.23	11.82±1.16	onset or peak of pubertal growth spurt	M3Cap, PP3u, DP3u	Class II Division 1(bilateral half or full-step class ll molar relationship), OJ min 4 mm, and mandibular retrognathia SNB<78	ANB>4°
Khoja *et al*., (2016)	TB	prospective	53	60	11.6 ± 1.71	11.15 ± 1.68	growing patients classified based on the CVM	CVM3, CVM4	Class II with mandibular retrognathia SNB<78, OJ ≥6 mm	ANB>5°
Lombardo *et al*., (2023)	TB & IMA	retrospective	35	15	12.0 ±1.3	10.9 ±1.1	CVM 3 patients	CVM3	Class II division 1 malocclusion, OJ 5-8 mm, bilateral full class ll or end-to-end molar relationships	ANB>4°

Saikoski *et al*., (2014)	TB	prospective	20	25	11.76 ±1.64	11.39 ±1.35	No skeletal maturation inclusion criterion	NA	Class II division 1 malocclusion	UNK
Tepedino *et al*., (2018)	TB	retrospective	23	15	10.8 ±1.1	10.7 ±0.9	CVM stage 3 at T1	CVM3	Overjet >5 mm, bilateral full Class II or end-to-end molar relationships	ANB>4°
Al. Subaie *et al*., (2024)	IMA	retrospective	50	20	11.98 ±2.18	11.75 ±1.59	puberty, but method UNK	UNK	Class II treated with IMA	UNK
Blackham (2020)	IMA	retrospective	32	32	13.15 ±1.37	13.07 ±1.35	puberty, but method UNK	CVM3	Class II treated with IMA	N/A
Ravera *et al*., (2021)	IMA	prospective	20	17	12.1 ±1.4	11.8 ±0.11	growing patients classified based on CVM	CVM3	Class II subjects based on Steiner analysis	3°<ANB <8°

Table 5: Quality appraisal results of selected studies

QUALITY CRITERIA	AlSubaie *et al*., (2024)	Blackham 2020	Gulec & Goymen 2018	Gulsoy & Yavan 2022	Khoja *et al*., (2016)	Lombardo *et al*., (2023)	Ravera *et al*., (2021)	Saikoski *et al*., (2014)	Tepedino *et al*., (2018)
I. Study design									
1. Objective: clearly formulated	1	1	1	1	1	1	1	1	1
2. Population—described	1	1	1	1	1	1	1	1	1
3. Selection criteria:									
Clearly described	0	0	0	1	1	1	1	1	1
adequate	0	0	0	1	1	1	1	1	1
4. Sample size:									
considered adequate	1	1	1	1	1	1	1	1	1
estimated before collection of data	1	1	1	1	1	1	1	1	1
5. baseline characteristics									
baseline characteristics clearly described	1	1	1	1	1	1	1	1	1
similarity between groups	1	1	1	1	1	1	1	1	1
6. Timing—prospective	0	0	0	0	1	0	1	1	0
7. Randomization	0	0	0	0	0	0	0	0	0
8. Co-interventions (0.present; 1.absent)	1	1	1	1	1	1	1	1	1
II. Study Measurements									
H. Measurement method appropriate to the objective	1	1	1	1	1	1	1	1	1
I. Blind measurement:									
Blinding of examiner	0	1	0	1	0	0	1	0	1
Blinding of statistician	0	0	0	0	0	0	0	0	0
J. Reliability described	1	1	1	1	1	1	1	1	1
III. Statistical Analysis									
k. Dropouts included in data analysis	0	0	0	0	0	0	0	0	0
L. Statistical analysis appropriate for data	1	1	1	1	1	1	1	1	1
M. Confounders included in analysis	0	0	0	0	1	0	0	0	0
N. Statistical significance level									
P value stated	1	1	1	1	1	1	1	1	1
Precision of the estimation (Confidence intervals)	0	0	0	0	0	1	1	0	0
Min number of 20 patients	1	1	1	1	1	1	1	1	1
TOTAL SCORE	12	13	12	15	16	15	17	15	15

Table 6: Population characteristics in the included studies

Article	Appliance	patients enrolled		Age		Females		Males		Tx duration		Appliance Wear time recommendation
		Tx-Group	Control group	Tx-Group	Control group	Tx-Group (N)	Control Group (N)	Tx-Group (N)	Control group (N)	Tx-Group	Control group (follow-up time)	
Gulec and Goymen (2018)	TB	15	10	12.18±2.19	12.77±1.62	8	7	7	3	11 months	6 months	22/24 h
Gulsoy & Yavan (2022)	TB	15	15	12.34±1.23	11.82±1.16	9	9	6	6	11.07±1.10 months	7.43±2.01 months	22/24 h
Khoja *et al*., (2016)	TB	53	60	11.6±1.71	11.15±1.68	25	36	28	24	8-12 months	12 months	Min. 12/24
Lombardo *et al*., (2023)	TB	35	15	12.0±1.3	10.9±1.1	17	11	18	4	UNK	UNK	22/24 h
Saikoski *et al*., (2014)	TB	20	25	11.76±1.64	11.39±1.35	9	11	11	14	1.13 year±0.4	1.07 year±0.7	20/24 h
Tepedino *et al*., (2018)	TB	23	15	10.8±1.1	10.7±0.9	12	UNK	11	UNK	UNK	UNK	16/24 h
Al. Subaie *et al*., (2024)	IMA	50	20	11.98±2.18	11.75±1.59	27 (54%)	7 (35%)	23 (46%)	13 (65%)	18.38±5.05 months	19.2±9.85 months	22/24 h
Blackham (2020)	IMA	32	32	13.15±1.37	13.07±1.35	UNK	UNK	UNK	UNK	356.53 days ±145.41	1.02 year±0.39	22/24 h
Lombardo *et al*., (2023)	IMA	21	15	11.2±1.1	10.9±1.1	12	11	9	4	UNK	N/A	22/24 h
Ravera *et al*., (2021)	IMA	20	17	12.1±1.4	11.8±0.11	UNK	UNK	UNK	UNK	17 months	18 months	22/24 h

Table 7: Mandibular position (SNB) and length (CoGn) post-treatment difference between the intervention (TB and CA) and non-treated control groups

Variable	**Groups compared**	**Study (Twin Block)**	**Treatment group (T2 – T1 mean difference) [degrees]**	**Control group (T2 – T1 mean difference) [degrees]**	**T2-T1 difference between treatment and control groups [degrees]**	**P value for difference between groups**
Mandibular position (degrees)	TB vs. controls	Gulec and Goymen (2018)	-0.66 ±2.00 (p=0.218)	0.3±1.50 (p=0.049*)	-096	UNK
		Gulsoy & Yavan (2022)	2.07 ±1.50 (p=0,000*)	0.46±1.10 (p=0.127)	1.61	**P = 0.009***
		Khoja *et al*., (2016) – CS 3 population	2.32 ± 1.28	0.73 ± 0.63	1.59	**P < 0.001****
		Khoja *et al*., (2016) – CS 4 population	1.15 ± 0.98	0.18 ± 1.03	0.97	**P = 0.016***
		Lombardo *et al*., (2023)	1.6 ±1.4	0.4 ±1.1	1.2	P = 0.145
		Saikoski *et al*., (2014)	1.27 ± 1.41	0.26 ± 1.29	1.21	P = 0.0152
		Tepedino *et al*., (2018)	2.23 ± 0.87	0.35 ± 1.07	1.87 ± 0.341	**P < 0.001***
	CA vs. controls	Al Subaie *et al*., (2024)	1.17 ± 2.63	− 0.04 ± 1.22	1.21	**P = 0.01***
		Blackham (2020)	0.93 ± 1.40 **	0.44 ± 0.99 *	0,49	P > 0.05
		Lombardo *et al*., (2023)	1.4 ± 3.2	0.4 ± 1.1	1.00	P = 0.337

		Ravera *et al*., (2021)	T1 =76.73 ± 4.25 T2 77.01 ± 4.08	T1= 77.53 ± 2.83 T2= 77.11 ± 3.53	1.11 ± 0.94	P = 0.247
Mandibular length (mm)	TB vs. controls	Gulec and Goymen (2018)	6.33 ± 7,04 (p=0.071)	-3.64 ± 6,04 (p=0.058)	9.97	**P=0.003***
		Gulsoy & Yavan (2022)	UNK	UNK	UNK	UNK
		Khoja *et al*., (2016) – CS 3 population	5.54 ± 3.26	1.24 ± 2.92	4,3	**P<0.001***
		Khoja *et al*., (2016) – CS 4 population	4.15 ± 3.53	1.65 ± 1.93	2,5	**P=0.027***
		Lombardo *et al*., (2023)	8. 4 ± 2.0	3.3 ± 1.2	5.1	**P=0.0000***
		Saikoski *et al*., (2014)	6.51 ± 3.13	2.34 ± 1.56	4,17	**P=0.0000***
		Tepedino *et al*., (2018)	8.69 ± 2.32	4.57 ± 1.22	4.12 ± 0.62	**P<0.001***
	CA vs. controls	Al Subaie *et al*., (2024)	5.74 ± 15.23	2.73 ± 4.73	3.01	P =0.21
		Blackham (2020)	3.35 ± 3.40 **	3.02 ± 3.10 **	0.33	P>0.05
		Lombardo *et al*., (2023)	8.3 ± 3.1	3.3 ± 1.2	5.00	**P=0.000***
		Ravera *et al*., (2021)	T1: 107.93 ± 8.89 T2: 117.39 ± 11.11	113.24 ± 6.18 113.07 ± 6.04	8.75 ± 3.93	**P=0.034***

Table 8: Maxillary position (SNA) post-treatment difference between the intervention (TB and CA) and non-treated control groups

Groups compared	**Study (Twin Block)**	**Treatment group (T2 – T1 mean SNA difference) [°]**	**Control group (T2 – T1 mean SNA difference) [°]**	**SNA T2-T1 difference between treatment and control groups [°]**	**Statistical significance (p-value) for difference between groups**
TB vs. controls	Gulec and Goymen (2018)	-1.98 ±2.33	0.03 ± 0.96	-1.95	NS
	Gulsoy & Yavan (2022)	0.07 ±1.36	0.41 ±1.17	-0.34	NS
	Khoja *et al*., (2016) – CS 3 population	0.32 ± 1.28	0.58 ± 0.75	-0.26	P=0.682
	Khoja *et al*., (2016) – CS 4 population	-0.69 ±0.75	0.41 ± 0.90	-1.10	**P < 0.001****
	Lombardo *et al*., (2023)	0.1 ±1.7	-0.7 ±1.5	0.80	P=0.392
	Saikoski *et al*., (2014)	-0.33 ± 1.69	-0.30 ± 1.47	-0.03	P=0.9564
	Tepedino *et al*., (2018)	0.28 ± 1.24	-0.53 ± 1.52	0.81	UNK
CA vs. controls	Al Subaie *et al*., (2024)	−0.48 ± 2.44	−0.57 ± 1.55	0.09	P=0.87
	Blackham (2020)	-0.20 ± 1.71	0.24 ± 1.41	- 0.44	NS
	Lombardo *et al*., (2023)	–0.4 ± 2.6	–0.7 ± 1.5	0.30	P=0.865
	Ravera *et al*., (2021)	T1: 81.84 ± 4.64 T2: 81.34 ± 4.10	T1: 82.62 ± 3.75 T2: 82.27 ± 3.37	0.30 ± 1.15	P=0.800

Table 9: Intermaxillary relationship (ANB) and Wits appraisal post-treatment difference between the intervention (TB and CA) and non-treated control groups

Variable	**Groups compared**	**Study**	**Treatment group (T2 – T1 mean difference)**	**Control group (T2 – T1 mean difference)**	**T2-T1 difference between treatment and control groups**	**P value for difference between groups**
ANB (degrees)	TB vs. controls	Gulec and Goymen (2018)	-1.29 ± 1.30	0.07 ± 1.06	-1.36	**P= 0.023****
		Gulsoy & Yavan (2022)	-1.98 ± 0.90	-0.0 5 ± 0.45	-1.93	**P= 0.000***
		Khoja *et al*., (2016) – CS 3 population	-2.00 ± 1.27	-0.15 ± 1.27	-1.85	**p< 0.001****
		Khoja *et al*., (2016) – CS 4 population	-1.84 ± 1.21	0.23 ± 1.00	-2.07	**p< 0.001****
		Lombardo *et al*., (2023)	–1.5 ± 1.4	0.2 ± 0.3	- 1.7	**P= 0.000***
		Saikoski *et al*., (2014)	-1.60 ± 1.55	-0.54 ± 1.10	-1.06	P= 0.0108
		Tepedino *et al*., (2018)	-1.96 ± 1.12	-0.89 ± 1.13	-1.07 ± 0.436	P= 0.044

	CA vs. controls	Al Subaie *et al*., (2024)	−1.66 ± 1.45	−0.51 ± 0.86	-1.15	**P= 0.001***
		Blackham (2020)	-1.11 ± 0.96 **	-0.20 ± 0.90	-0.9	**P ≤ 0.01***
		Lombardo *et al*., (2023)	–1.5 ± 1.5	0.2 ± 0.3	–1.7	**P= 0.001***
		Ravera *et al.,* (2021)	5.12 ± 2.36 4.28 ± 2.17	5.10 ± 2.19 5.17 ± 1.79	-0.91 ± 0.69	P= 0.195
Wits (mm)	TB vs. controls	Gulec and Goymen (2018)	-2.61 ±2.55	0.28 ±1.24	-2.89	UNK
		Gulsoy & Yavan (2022)	UNK	UNK	UNK	UNK
		Khoja *et al*., (2016) – CS 3 population	UNK	UNK	UNK	UNK
		Khoja *et al*., (2016) – CS 4 population	UNK	UNK	UNK	UNK
		Lombardo *et al*., (2023)	–1.1 ± 2.9	0.4 ± 2.3	–1.5	P= 0.141
		Saikoski *et al*., (2014)	-2.16 ± 2.78	-0.34 ± 2.30	-2.5	P= 0.0210
		Tepedino *et al*., (2018)	-2.85 ± 1.89	0.4 ± 2.03	-3.25 ± 0.79	**P <0.001***
	CA vs. controls	Al Subaie *et al*., (2024)	−3.44 ± 2.71	0.29 ± 0.99	-3.73	**P= 0.001***
		Blackham (2020)	-2.42 ± 1.99 **	0.41 ± 2.22	-2.83	**p≤ 0.01***
		Lombardo *et al*., (2023)	–0.8 ± 2.4	0.4 ± 2.3	–1.2	P= 0.346
		Ravera *et al.,* (2021)	3.29 ± 2.67 1.83 ± 2.65	0.52 ± 4.19 2.51 ± 3.32	-3.65± 1.29	**P= 0.00845***

Table 10: Mandibular plane (MP) inclination post-treatment difference between the intervention (TB and CA) and non-treated control groups

Groups compared	**Study (Twin Block)**	**Treatment group (T2 – T1 mean MP inclination difference) [°]**	**Control group (T2 – T1 mean MP inclination difference) [°]**	**MP inclination T2-T1 difference between treatment and control groups**	**P value for difference between groups**
TB vs. controls	Gulec and Goymen (2018) (SN^GoGn)	1.29° ± 2.14	-1.12° ± 2.18	2.41	**P= 0.010***
	Gulsoy & Yavan (2022) (SN^GoGn)	0.27° ±1.18	0.20° ±0.66	0.07	P>0.05
	Khoja *et al*., (2016) - CS 3 population (SNGoGn)	0.14° ± 2.55	-0.28° ± 0.97	0.42	P= 0.629
	Khoja *et al*., (2016) CS 4 population (SNGoGn)	1.84° ± 2.57	0.23° ± 1.00	1.61	**P= 0.024***
	Lombardo *et al*., (2023) (SNGoGn) (MMPA)	–0.8° ± 1.7 - 0.4° ± 2.5	0.9° ± 1.1 0.6° ± 0.8	–1.7 -1.2	P= 0.637 P= 0.005
	Saikoski *et al*., (2014) (SNGoGn) (FMPA)	-0.53° ± 1.67 -0.68° ± 2.21	-0.92 ± 2.09 -0.57 ± 2.57	0.39 -0.11	P= 0.4911 P= 0.8877
	Tepedino *et al*., (2018) (FMPA)	-0.66 ± 1.51	-0.8± 1.03	0.14 ± 0.64	P= 0.973
CA vs. controls	Al Subaie *et al*., (2024) (SN^GoGn) (MMPA)	−0.41° ± 2.91 −0.76° ± 1.89	−0.09° ± 1.96 −0.41° ± 2.20	0.5 0.35	P= 0.597 P= 0.533
	Blackham (2020) (SN^GoGn) (MMPA)	-0.03° ± 1.78 0.00° ± 1.81	-0.58° ± 2.06 -0.65° ± 1.97	0.55 0.65	NS NS
	Lombardo *et al*., (2023) (SN^GoGn) (MMPA)	–1.7°± 2.0 –0.5°± 3.1	0.9° ± 1.1 0.6° ± 0.8	2.6 1.1	P= 0.811 **P= 0.000***
	Ravera *et al*., (2021) (SN^GoGn) (MMPA)	32.57° ± 5.70 32.48° ± 6.33 24.17° ± 5.71 23.91° ± 5.28	32.53° ± 4.55 30.81° ± 6.20 26.6° ± 4.55 24.26° ± 5.18	1.41 ± 1,24 2.40 ± 0,88	P= 0,263 **P= 0.01065***

Table 11: Upper (U1 position) and lower (IMPA) incisor's position post-treatment difference between the intervention (TB and CA) and non-treated control groups

Variable	Groups compared	Study	Treatment group (T2 – T1 mean difference) [°]	Control group (T2 – T1 mean difference) [°]	T2-T1 difference between treatment and control groups [°]	P value for difference between groups
Upper incisors	TB vs. controls	Gulec and Goymen (2018) U1^FHP	-4.75 ± 7.53	1.71 ± 4.35	-6.46	**NS**
		Gulsoy & Yavan (2022) U1^PP	-5.15 ± 5.89	-0.25 ± 4.47	-4.90	**P= 0.044***
		Khoja *et al*., (2016) CS 3 population U1^SN	-1.68 ± 4.30	1.30 ± 2.90	-2.98	**P= 0.013***
		Khoja *et al*., (2016) CS 4 population U1^SN	-6.77 ± 3.51	1.00 ± 2.55	-7.77	**P < 0.001****
		Lombardo *et al*., (2023) U1^PP	0.10 ± 1.70	–0.70 ±1.50	–1.60	UNK
		Saikoski *et al*., (2014) U1^PP	-7.00 ± 6.41	-0.24 ± 3.93	-6.76	**P= 0.0001***
		Tepedino *et al*., (2018) U1^PP	-2.58 ± 3.95	-0.74 ± 2.55	-1.84 ± 1.12	P= 0.245
	CA vs. controls	Al Subaie *et al*., (2024) U1^PP	−0.37 ± 12.58	0.63 ± 3.27	-1.00	P= 0.606
		Blackham (2020) U1^PP	-0.14 ± 7.13	0.56 ± 3.11	-0.70	NS
		Lombardo *et al*., (2023) U1^PP	–0.40 ± 2.60	–0.70± 1.50	–1.10	UNK
		Ravera *et al*., (2021) U1^PP	111.35 ± 8.88 111.55 ± 4.41	109.80 ± 4.45 106.07 ± 2.89	5.95 ± 7.13	P= 0410
Lower incisors	TB vs. controls	Gulec and Goymen (2018)	3.25 ± 6.31	0.75 ± 2.30	2.50	NS
		Gulsoy & Yavan (2022)	3.80 ± 4.78	0.33 ± 1.95	3.47	**P=0.039***
		Khoja *et al*., (2016) – CS 3 population	3.00 ± 3.10	0.61 ± 2.38	2.39	**P=0.005***
		Khoja *et al*., (2016) – CS 4 population	6.15 ± 4.35	0.67 ± 5.10	5.48	**P=0.005***
		Lombardo *et al*., (2023)	1.6 ± 1.40	0.4 ± 1.10	1.20	P=0.969
		Saikoski *et al*., (2014)	5.51 ± 6.33	1.20 ± 3.53	4.30	P=0.0060
		Tepedino *et al*., (2018)	0.20 ± 3.51	1.42 ± 2.12	-1.22 ± 0.98	P=0.438
	CA vs. controls	Al Subaie *et al*., (2024)	1.53 ± 7.14	0.11 ± 3.66	1.42	P=0.278
		Blackham (2020)	-0.58 ± 4.33	-0.69 ± 3.22	0.11	NS
		Lombardo *et al*., (2023)	1.40 ± 3.2	0.40 ±1.1	1.00	P=0.603
		Ravera *et al*., (2021)	100.73 ± 5.60 99.05 ± 6.13	97.23 ± 7.03 98.34 ± 6.69	-2.97 ±1.50	P=0.057

Table 12: Overjet and overbite post-treatment difference between the intervention (TB and CA) and non-treated control groups

Variable	Groups compared	Study (Twin Block)	Treatment group (T2 – T1 mean difference) [mm]	Control group (T2 – T1 mean difference) [mm]	T2-T1 difference between treatment and control groups [mm]	P value for difference between groups
Overjet	TB vs. controls	Gulec and Goymen (2018)	-3.35 ± 2.30	0.13 ± 1.03	-3.48	**P = 0.000****
		Gulsoy & Yavan (2022)	-6.04 ± 1.98	-0.18 ± 1.53	-5.86	**P = 0.0000***
		Khoja *et al*., (2016) – CS 3 population	-7.25 ± 2.20	0.14 ± 1.01	-7.39	**P < 0.001****
		Khoja *et al.,* (2016) – CS 4 population	-6.51 ±1.73	-0.52 ± 1.24	-5.99	**P < 0.001****
		Lombardo *et al*., (2023)	-1.60 ± 4.80	0.00 ± 0.0	-1.60	**P = 0.0000***

		Saikoski *et al*., (2014)	-5.29 ± 2.20	-0.18 ± 1.28	-5.11	**P = 0.0000**
		Tepedino *et al*., (2018)	-3.70 ± 1.01	-0.25 ± 0.79	-3.45 ± 0.308	**P < 0.001***
	CA vs. controls	Al Subaie *et al*., (2024)	− 3.03 ± 2.54	− 0.08 ± 1.18	-2.95	**P < 0.001***
		Blackham (2020)	-1.83 ± 1.52	-0.02 ± 0.95	-1.81	**P ≤ 0.01***
		Lombardo *et al*., (2023)	-0.5 ± 7.0	0.00 ± 0.0	-0.5	**P = 0.000***
		Ravera *et al*., (2021)	UNK	UNK	UNK	UNK
Overbite	TB vs. controls	Gulec and Goymen (2018)	-0.03±1.98	-0.43±1.20	0.40	NS
		Gulsoy & Yavan (2022)	-1.78±2.08	0.17±1.16	-1.95	**P= 0.010***
		Khoja *et al*., (2016) – CS 3 population	UNK	UNK	UNK	UNK
		Khoja *et al*., (2016) – CS 4 population	UNK	UNK	UNK	UNK
		Lombardo *et al*., (2023)	1.10 ± 4.30	0.70 ± 1.60	0.40	**P= 0.000***
		Saikoski *et al*., (2014)	-1.55 ± 2.73	0.01 ± 1.39	-1.56	P =0.0169
		Tepedino *et al*., (2018)	-1.10 ± 1.50	0.21 ± 1.07	-1.31	NS
	CA vs. controls	Al Subaie *et al*., (2024)	1.13 ± 2.87	− 0.46 ± 1.3	0.67	0.184
		Blackham (2020)	-1.13 ± 1.65	- 0.21 ± 1.25	-0.92	NS
		Lombardo *et al*., (2023)	–1.00 ± 7.90	0.70 ± 1.60	–1.7	**0.001***
		Ravera *et al*., (2021)	UNK	UNK	UNK	UNK

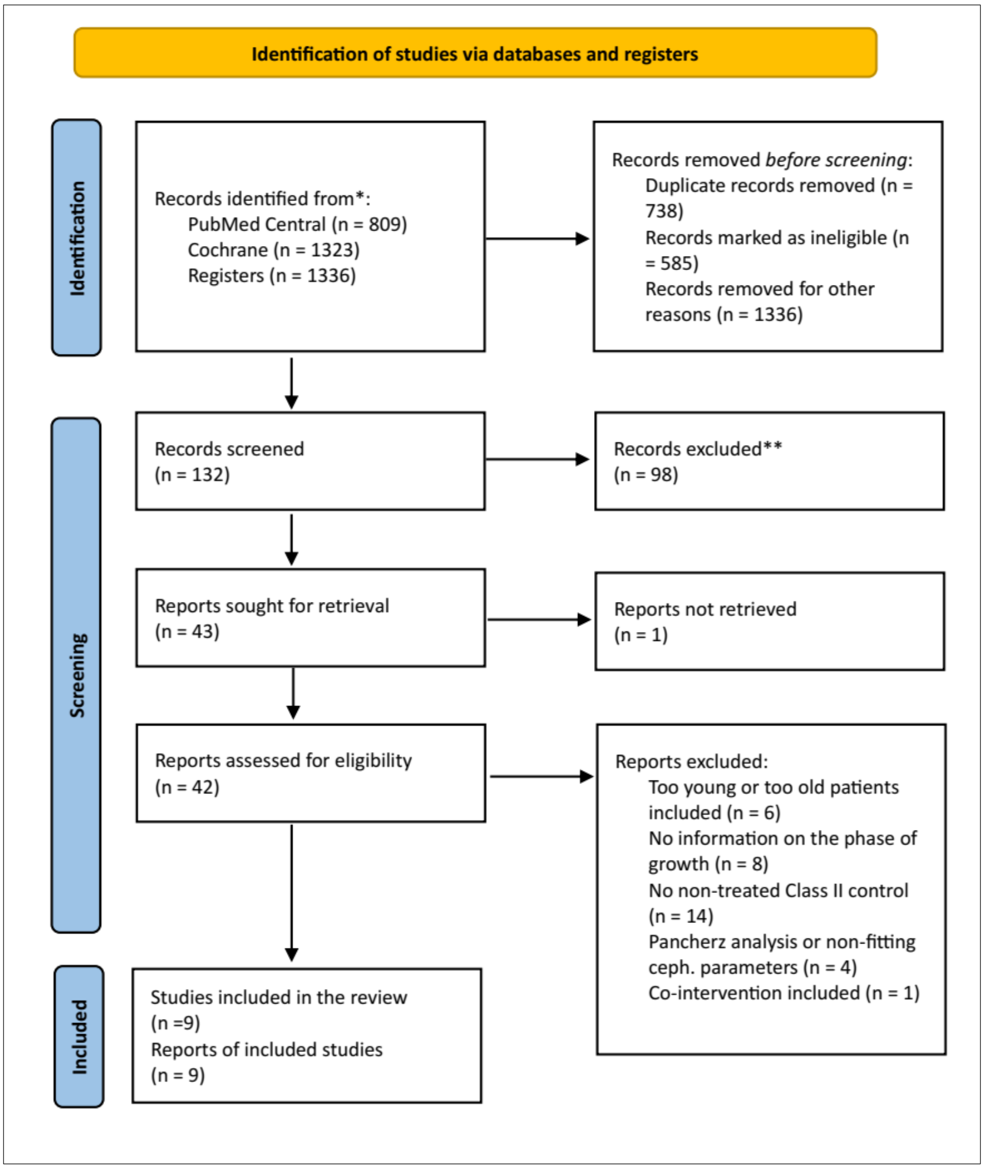

Figure 1: PRISMA 2020 flow diagram for database search results

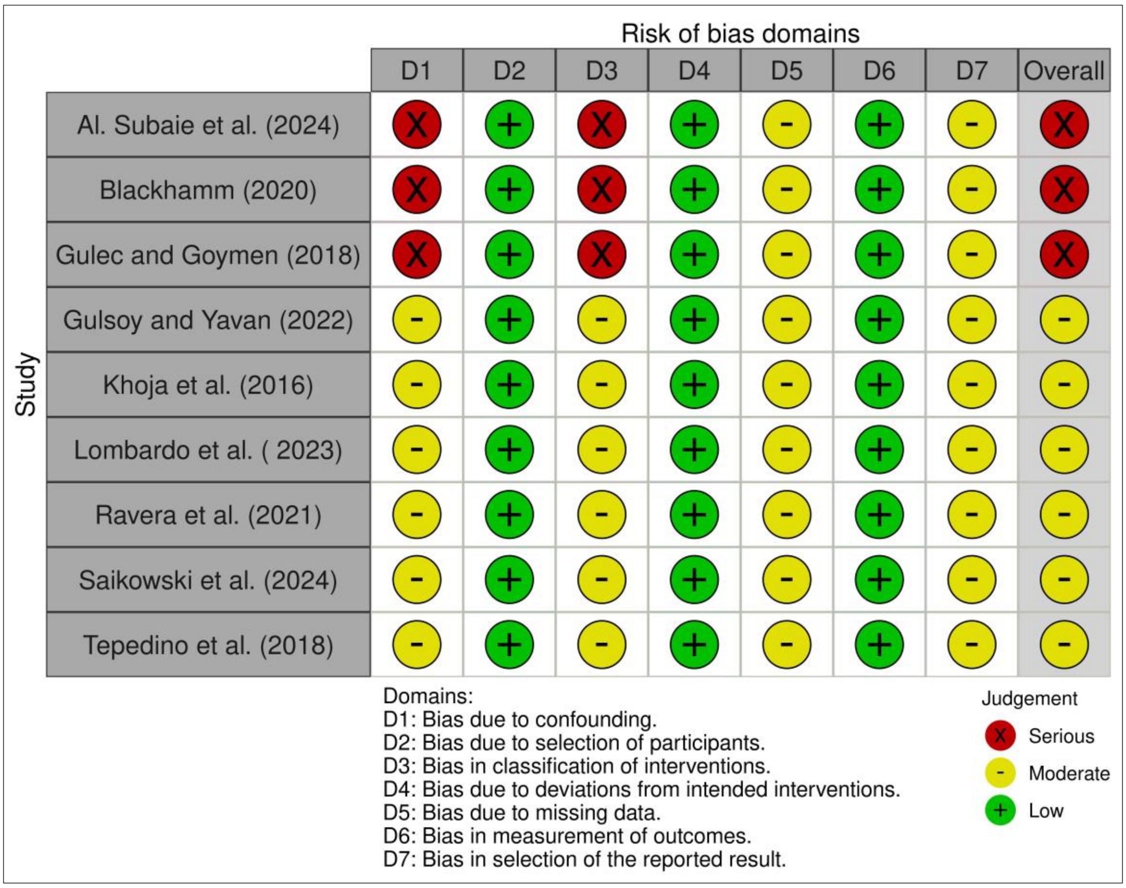

Figure 2: Risk of bias for the selected articles (ROBVIS)

CONCLUSION

Both TB and CAs are effective in treating skeletal Class II malocclusion with mandibular retrognathia during the pubertal growth phase. Improvements in sagittal relationships are primarily driven by mandibular advancement, reflected by increased SNB and reduced ANB angles. TB demonstrated slightly greater skeletal effects, possibly due to more rigid mandibular positioning, although both appliances significantly enhanced mandibular length compared to natural growth.

Dentoalveolar changes were also observed, particularly overjet reduction, which was more pronounced with TB. CAs provided better control of incisor inclination, while vertical effects were minimal with both appliances.

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